POINTMAN

Turning Virtual Reality into a More Realistic and Effective Infantry Training Ground

With the invention of Pointman, a new desktop control, trainees can now realistically perform actions in VBS2, the training simulator used by the U.S. Marine Corps. NRL's Immersive Simulation Section has developed a novel user interface that will provide the Corps with the capability to supplement live training by means of a portable computer-based system that can train dangerous situations without risking life or limb.

For a generation who grew up with game controllers practically as appendages, how does a new, more realistic interface better accomplish the difficult task of bringing the battlefield to the desktop? By making the simulated movement more natural, fluid, and reflective of the real-world engagement experience; by incorporating correct, realistic tactical movements into the virtual reality experience; and by using enhanced inputs (dual joysticks; sliding foot-pedals to simulate stepping, squatting, and lying flat; and a head-tracking sensor).

Each of these features is novel and increases the effectiveness of the training. For instance, applying dual joysticks in a novel way allows the user to control the heading (the direction that the body of the avatar, the virtual soldier, faces) and course (the direction of movement of the avatar) independently. That means that the avatar can turn to look or shoot without redirecting its movement along a path, enabling both scanning for enemies and coordinating actions with squad members.

In combat, the pointman leads the patrol and is the first to encounter the enemy. With NRL's Pointman, today's soldiers can get additional assistance in practicing the tactical team movement involved with dismounted combat without risking injury and without DoD incurring extra logistical expense. This invention, then, even more importantly than saving money, can help save our soldiers' lives. And isn't that the point, after all?

A Novel User Interface Controller for Dismounted Infantry Training

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For more than a decade, the Immersive Simulation Section has developed novel user interfaces for U.S. Marine Corps (USMC) infantry training simulators that let users interact in the 3D virtual world with close to the same abilities and constraints people have in the real world, in terms of moving through the environment and coordinating with teammates. Pointman is a new desktop control interface that combines a dual-joystick gamepad, head tracking, and sliding foot-pedals (inexpensive rudder pedals used with flight simulator games) that, for the first time, gives users the capability to apply correct tactical infantry movements using a desktop system. The USMC has adopted VBS2 (Virtual BattleSpace-2), an infantry and combined arms desktop training simulator to supplement live training. VBS2 is a product of Bohemia Interactive and will be used within the framework of the USMC's Deployable Virtual Training Environment (DVTE). Training simulators present dangerous situations without risking injury or accidents. They can represent any location that has been modeled, have a small footprint, and are deployable. They are less costly because they do not require travel to physical training sites and do not use consumables. The USMC recognizes the advantages of Pointman for increasing training effectiveness and has endorsed Pointman's integration with VBS2 through the Office of Naval Research's Rapid Technology Transition (RTT) Program and in cooperation with the USMC Program Manager Training Systems office (PMTRASYS) in Orlando, Florida.

INTRODUCTION

Desktop training simulators have the potential to provide training anytime and anywhere. A multiplayer training simulator can engage a whole squad in one action. A missing component in today's desktop simulators is a user interface controller that allows trainees to execute realistic military tactics, techniques, and procedures. Tactical movement relies heavily on the ability to look around (scan) while moving along any chosen path. Figure 1 illustrates the characteristics of tactical movement for moving around a corner in a high-threat environment. The objective is to clear the corner while minimizing the person's exposure to a threat. The action requires incrementally "pie-ing" the corner, turning the upper body and rifle together as a unit to face the corner, while moving down the hallway and focusing attention on the area just past the corner's edge.

The ideal user interface would enable the user to fully control the movement of the user's avatar (virtual body) in the virtual world. This movement is characterized by the avatar's heading (the direction in which the avatar's body faces) and course (the direction in which the avatar moves). Current dual-joystick gamepad con-

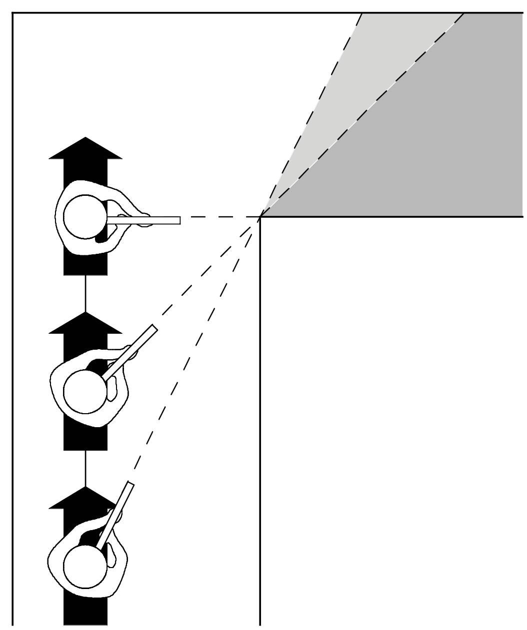

FIGURE 1
Turning the heading toward a corner while maintaining a straight course is a tactically correct way to clear a corner (referred to as *pie-ing* a corner). Direction of movement is represented by the arrow and heading coincides with the direction of aim.

trollers for first-person shooting games make it difficult to execute tactical movements because of limitations in the control mapping, which conflate the control over the avatar's heading and course. The problem is that the joystick used to turn the heading also redirects the course. The right joystick is a rate control that turns the heading and course together, while the left is a directional control that changes the course relative to the heading. Tactics for first-person shooter games reflect this control deficiency by emphasizing artificial strafing motions: moving sideways and spiraling toward or away from the target.

From its inception, the goal in developing Pointman was to create an interface that allows the user to move his or her avatar in a tactically correct manner. We learned a great deal about control over natural and tactical movement in developing Gaiter, a full-body immersive interface that uses a head-mounted display to surround the user in the virtual world and tracks the user's body segments in six degrees of freedom to provide direct interaction.[1] With Gaiter, the user steps in place to move the avatar through the virtual world and physically turns to rotate. The ability to turn naturally is central to Gaiter because it allows the user to turn immediately toward or away from any sight or sound.

The design goal for both Gaiter and Pointman is for tasks in the virtual world to be performed at the same rate, accuracy, and effort as they are in the real world to maintain timing and scale.[2] Having close to the same capability in the virtual world as a person has in the real world makes it more likely that skills developed in one will transfer to the other. For example, the cadence set when stepping in place with Gaiter or using Pointman's sliding foot-pedals is mapped to a real-world walking or running cadence on a moment-by-moment basis to give the user a realistic sense of distance traveled.

OVERVIEW OF POINTMAN

The Pointman user interface consists of a conventional dual-joystick gamepad for directing motion and weapons handling; sliding foot-pedals to control stepping; head tracking for directing the view and aim; and a desktop display (Fig. 2). The components combine to allow the user to control the actions of the user's avatar in a natural manner.

Unlike conventional gamepad controls, both joysticks on the gamepad are applied as directional controls. The user simply points the joystick in the direction the avatar should move or turn. Figure 3 shows the mapping of Pointman's dual-joystick gamepad. To turn smoothly, the right joystick is pushed forward and slid against the circular outer rim to continuously redirect the heading. To turn quickly in a known direction, the joystick is pushed in the desired direction from the neutral centered position. The user's avatar then turns at the maximum rate a person can physically turn in that situation. The left joystick controls the stepping direction (forward, backwards, sideways, or in any diagonal direction). The length of the avatar's stride and stepping cadence are expressed via sliding foot-pedals, which mimic a person's reciprocal foot motion when walking or running. Pointman lets users directly sense how far their avatar has turned or traveled, even with their eyes closed: users feel their avatars' alignment through the position of the joysticks and perceive how far they have traveled by the amount they have stepped.

Using the right joystick alone while operating the sliding foot-pedals advances the avatar in a forward direction relative to the current heading. People spend most of their time walking along paths in this way (for example, down a hall) and the design of Pointman makes such common acts easy to do. Using the left joystick alone while operating the foot-pedals translates the avatar along the indicated course while keeping the avatar's heading constant.

The real power of Pointman comes when the joysticks are jointly engaged. Working together, they provide independent control over heading and course: the right joystick turns the avatar (for example, to face a target) while the left sets the avatar's direction of movement. This independent control over heading and course is what lets the user scan while moving along a path.

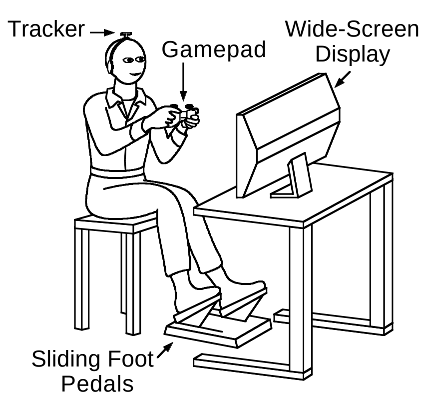

FIGURE 2
Pointman user interface with dual joystick gamepad, head tracking, and sliding foot-pedals.

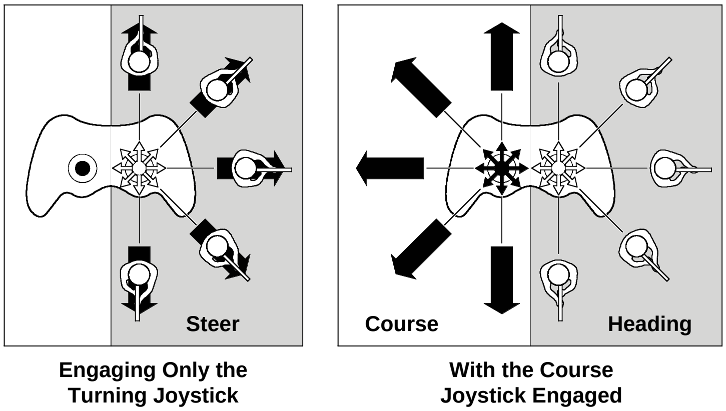

FIGURE 3
Mapping of Pointman's dual joystick gamepad to control the avatar's movement.

Weapons handling is accomplished through button presses on the gamepad. One button is the trigger and another cycles through the different ways of carrying the rifle: slung, carry, ready, and aim. A change in posture is also indicated through a button press, cycling through standing, prone, seated. Tilting the foot-pedals (similar to an accelerator pedal) adjusts the height of a posture; for example, with standing, pushing the pedals down moves the avatar from an upright posture to a crouch.

A three-degree-of-freedom (orientation only) tracker or a six-degree-of-freedom (orientation and translation) tracker worn on the user's head provides control over viewing and aiming. Head tracking controls the yaw (turning about the vertical axis), pitch (tilting up and down), and roll (tilting left and right) of the avatar's head and aim relative to the joystick-directed heading. The yaw derived from the head tracking data is added to the current heading to turn the view an additional amount (limited by how far the user can turn his or her head while seated in front of the desktop display). Since the degree to which the user can pitch his or her head up and down while viewing the desktop display is limited, the pitch derived from the head tracking data is amplified to allow the avatar to look directly up or down in the virtual world. If the tracker provides six degrees of freedom, the user can direct the avatar's upper body to lean forward, backward, and side-to-side independently of how the head is oriented, further increasing the realism. The direction of aim is, therefore, linked to both the heading set by the joystick and the direction of view, allowing the head, upper body, and rifle to be rotated as a unit to maintain an indexed shooting posture as is done in the real world. With six-degree-of-freedom tracking, users can also lean to shoot from behind cover.

USER'S AVATAR

The Immersive Simulation Section has pioneered the use of a fully articulated user avatar continuously driven in real time either by the user's own body motion or through control actions. An articulated avatar is used with both Gaiter and Pointman. A central part of the integration effort is to add an articulated avatar to VBS2.

Traditionally, avatars in first-person shooter games, including VBS2, use prerecorded animation sequences to portray the user's actions. A user indicates that the avatar should move forward by deflecting a joystick or pushing a button, and an animation sequence of a walking or running avatar is played. In contrast, Pointman lets the user directly control his or her avatar. The sliding foot-pedals control the avatar's stepping motion, course and heading are controlled with the dual joysticks, and because the user's head is tracked, the user's avatar turns to look in the same direction that the user's head turns. In other words, with Pointman, the avatar moves in correspondence with the user's actions to an unprecedented degree for a desktop control.

Users operate in first person and see the virtual world out of their avatars' eyes. The avatar is fully rendered so the user sees his or her avatar's arms, legs, and feet. Users also see their teammates as fully articulated avatars acting in the virtual world. The challenge is to realistically portray the actions performed by the user's avatar under direct, continuous control. Being able to act in a realistic manner in the virtual world gives the user a sense of perspective, relative distance, and presence in the environment. Watching the actions of teammates' avatars gives a better sense of their intent. Having a finer level of control in the virtual world leads to a fuller range of expression, greater situational awareness, better communication among immersed teammates, and support for cooperative action.

INTEGRATION WITH VIRTUAL BATTLESPACE-2

VBS2 currently uses a keyboard and mouse interface or conventional gamepad with thumbsticks and buttons, and prerecorded animations for avatar movement. Enabling users to execute correct tactical methods in the virtual world requires the integration

of both the Pointman user interface and an articulated avatar continuously directed in real time. NRL's Immersive Simulation Section has developed a detailed VBS2-Pointman Interface Specification that allows Pointman to direct the user's avatar in VBS2. The goal is to create a Pointman-enhanced version of the VBS2 training simulator, adding more realistic interaction while minimizing latency and communication overload. Figure 4 shows the user's avatar as controlled by Pointman and rendered in VBS2.

The VBS2 integration coincides with new research to extend the range of behaviors supported by Pointman to meet the demands of military action in urban terrain. The user's avatar needs to not only stand but also crouch and sit while handling a rifle. We have conducted research in fluid control over the avatar's body posture and engagement stance so that the avatar can transition between poses with the same timing and constraint people use in the real world. Figure 5 shows the design for accomplishing a smooth transition

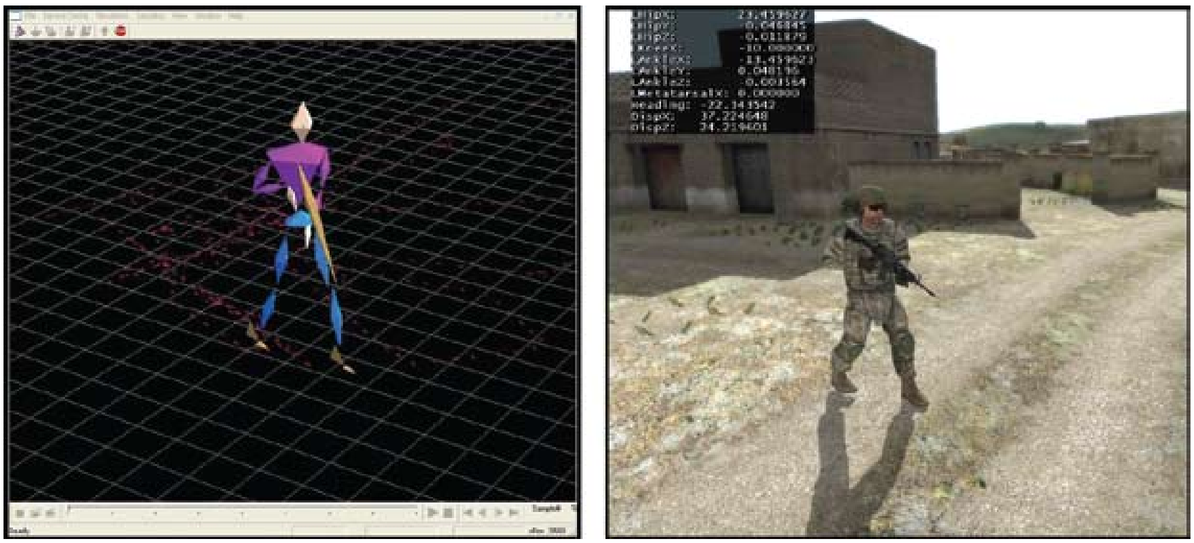

FIGURE 4
Integration of Pointman with Virtual BattleSpace-2. The left panel shows the user's avatar as controlled by Pointman; the right panel is the avatar as rendered in VBS2.

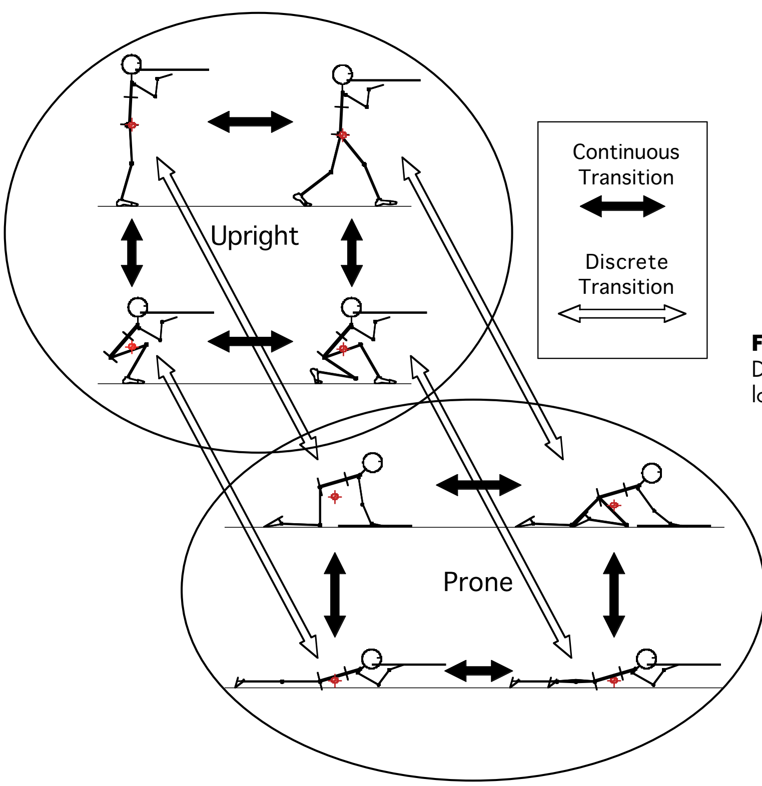

FIGURE 5
Design of the smooth transition between a high and low stance in upright and prone postures.

between a high and low stance in upright and prone postures. The challenge has been to make the different means of controlling the avatar's stance and movement work together to express the user's intent in a natural manner.

CONCLUSIONS

Pointman is a new user interface that gives users the ability to execute realistic tactical infantry movements in a desktop environment. The military has a growing interest in using desktop simulators for training because they are portable, relatively inexpensive, and can support a large number of users. Four U.S. Marine Corps Generals who visited our lab recognized Pointman's advantages. While Pointman's independent control over moving and looking remains the core of the user interface, a key effort has been researching how to make the transition between avatar postures and stances more fluid and natural. The final result will be a desktop training simulator that provides realistic control over action to support teaching the full range of tactics, techniques, and procedures used in infantry operations.

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